

the characters noted above; parietals are present, but there is no basisphenoid. Vertebrae 30 to 36 (*Gambusia* 32, *Belonesox* 36, *Pæcilia*, *Mollienisia*, and *Xiphophorus* 30 or 31).

The principal genera are *Belonesox*, *Gambusia*, *Petalosoma*, *Glaridichthys*, *Cnesterodon*, *Heterandria*, *Pæcilia*, *Girardinus*, *Acanthophaeus*, *Phalloptychus*, *Phalloceros*.

In *Belonesox* the jaws are produced and the teeth cardiform; some of the others are carnivorous and have the mouth and dentition of a *Fundulus*, but these are closely related to those mud-eating forms which have a small transverse mouth, movable compressed teeth, and the rami of the lower jaw loosely connected. All the species are American, ranging on the coasts and in the rivers from the southern United States to the La Plata, and especially abounding in Central America and the West Indies. The males of some of the species are among the smallest known fishes.

EXPLANATION OF PLATE VIII.

Goodea atripinnis.

Fig. 1. Hyopalatine and opercular bones (internal view). *pal*, palatine; *q*, quadrate; *ms*, mesopterygoid; *hm*, hyomandibular; *sy*, symplectic; *op*, operculum; *sop*, suboperculum; *iop*, interoperculum.

Fig. 2. Pectoral arch (except post-temporal and supra-cleithrum). *cl*, cleithrum; *pcl*, post-cleithrum; *sc*, hypercoracoid; *cor*, hypocoracoid; *r*, radials.

Figs. 3-5. Skull: 3, from behind; 4, from above; 5, from below. *soc*, supraoccipital; *boc*, basioccipital; *eoc*, exoccipital; *epo*, epiotic; *opo*, opisthotic; *spo*, sphenotic; *pto*, pterotic; *pro*, pro-otic; *asp*, alisphenoid; *psp*, parasphenoid; *v*, vomer; *eth*, mesethmoid; *leth*, lateral ethmoid; *n*, nasal; *por*, præorbital; *f*, frontal; *p*, parietal; *ptt*, post-temporal.

XXXVI.—The Classification of the Teleostean Fishes of the Order Syngnathi. By C. TATE REGAN, M.A.

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[Plate IX.]

THE order Syngnathi (Pharyngognathi malacopterygii of Johannes Müller) may be shortly diagnosed as comprising malacopterous physoclists with the lower pharyngeals completely united. In these fishes the dorsal fin is placed far back, above the anal, the branched rays of the caudal are only 13 in number, the pectorals are placed high, and the

pelvic fins are abdominal, 6-rayed. The scales are thin and cycloid, and the lateral line runs very low. The præmaxillaries are non-protractile and the maxillaries enter the border of the mouth to a greater or less extent; the lower jaw includes a sesamoid articulare, composed of a laminar portion adherent to the inner face of the articulare, and of a rather stout process which projects above the edge of the jaw; the hyo-palatine and opercular bones are normally developed; the branchiostegals number from 9 to 15; the more or less enlarged third upper pharyngeals are denticiferous, opposed to the united lower pharyngeals; the fourth are small or absent; the upper surface of the cranium is flattish, without crests; the nasals are superior in position, firmly united to the frontals and ethmoid; the upper edge of the large præorbital is attached to the outer edge of the nasal, at right angles to the latter; the parietals, when present, are very small, separated by the supraoccipital; there is no orbitosphenoid; the well-separated alisphenoids are not always recognizable as distinct elements; a basi-sphenoid is present and the myodome has an osseous roof; the opisthotic is absent, and the epiotic and pterotic are produced backwards into a laminar expansion, with which a similar projection of the exoccipital is usually united. The post-temporal is usually simple, attached to the epiotic and pterotic lamina, but there may be a very small inner fork joining the exoccipital; the supra-cleithrum is reduced; the short pectoral radials are rigidly united with the hypercoracoid and hypocoracoid, and the latter is expanded; there is no mesocoracoid. The vertebræ are numerous, the centra and arches are ankylosed, and the ribs and epipleurals are inserted together on the transverse processes, the ribs commencing on the third vertebra; the hypurals are reduced in number and ankylosed with the last centrum, which bears a prominent horizontal ridge on each side.

The Synentognathi are an isolated group, without evident close relationship to any other fishes, but showing certain resemblances to the Microcyprini. The large number of branchiostegals, the absence of spinous fin-rays, the truly abdominal pelvic fins, the mouth-structure, and other characters indicate their derivation from malacopterous physostomes; they do not appear to be even remotely allied to the Percesoces, which I am now disposed to unite with the Percomorphi, for I cannot believe that two groups so precisely similar in their anatomy are not closely related, nor that they have independently acquired the combination of a spinous dorsal, 3 anal spines, 15 branched caudal rays, pelvic fins anterior, of a spine and 5 soft rays, and 24 vertebræ.

The fishes of this order have often been considered to form but a single family, Scomberocidæ (Günth. Cat. Fish. vi. p. 234; Bouleng. Camb. Nat. Hist. Fish. p. 637). In 1878 Cope (Proc. Amer. Phil. Soc. xvii. p. 695) proposed to place *Belone* in a separate family, the possession of a coronoid bone and of zygapophyses being said to distinguish it from the Exocætidæ. In 1895 (Proc. U.S. Nat. Mus. xviii. p. 167) Dr. Gill put forward the following scheme:—

Family EXOCÆTIDÆ.

Synentognathi with the supramaxillaries [maxillaries] only in contact with the intermaxillaries [premaxillaries], the mandible with a reduced intradentary bone, the hypopharyngeals united in a broad triangular body, the third pair of epipharyngeals much enlarged, those of the fourth pair aborted or united with the third, and the vertebræ without zygapophysoid processes.

Subfamily SCOMBERESOCINÆ.

Exocætidæ with both jaws more or less elongated and attenuated forward, pectoral fins moderate, and the epipharyngeals of the third pair separate.

Subfamily EXOCÆFINÆ.

Exocætidæ with both jaws rounded or simply angulated forward, pectoral fins enlarged and adapted for sustentation of the body in the air, and the epipharyngeals of the third pair separate.

Subfamily HEMIRHAMPHINÆ.

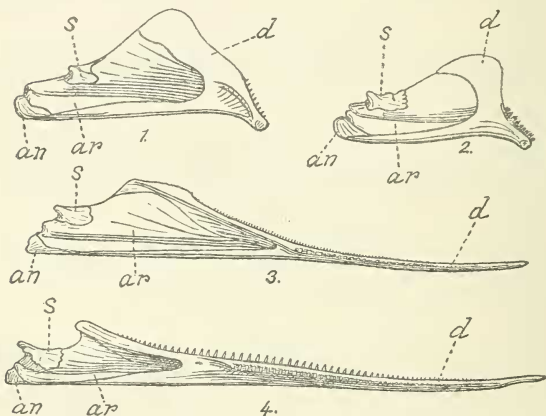
Exocætidæ with the upper jaw angulate and the lower produced into an elongated beak, pectoral fins moderate or little enlarged, and the epipharyngeals of the third pair closely united in a transverse plate.

Family ESOCIDÆ * [BELONIDÆ].

Synentognathi with the supramaxillaries united by suture with the intermaxillaries, the mandible with an elongated intradentary bone, the hypopharyngeals united in a narrow body, the third pair of epipharyngeals little enlarged, those of the fourth pair distinct from the third and from each other and the vertebræ with distinct zygapophysoid processes.

* There can be no question that Artedi and Linnæus regarded the pike, *Esox lucius*, as the type of the genus *Esox*. Linnæus, in the sixth edition of the 'Systema Naturæ,' included three species in the genus—1. *lucius*, 2. *belone*, 3. *acus*; and in the 'Fauna Suecica' two—1. *lucius*, 2. *belone*. Artedi, in the 'Bibliotheca Ichthyologica' (1738), also placed the pike, *Esox rostro plagioplateo*, as the first species of the genus *Esox*, and as the first synonym gave *Esox*, Pliny. Thus, by the rule of tautonymy, *E. lucius* is the type of *Esox*, and Rafinesque's restriction of the name to *E. belone* may be ignored. The fact that in all probability Artedi was mistaken in thinking that Pliny's *Esox* was the pike has no importance in this connexion.

This classification was adopted by Jordan and Evermann (Bull. U.S. Nat. Mus. xlvii. 1896, p. 707) except that the subfamilies were given family rank. The diagnostic characters were practically unchanged, except that the position and size of the additional bone in the lower jaw were correctly indicated. Ridewood (P. Z. S. 1904, ii. p. 72) has pointed out that the names "addentary" and "intradentary" proposed by Gill were based on a misconception; the best name for this bone is that given by Ridewood, namely "sesamoid articulare." The development of this bone is more or less proportional to the length of the jaw and the strength of the dentition; it is largest in *Tylosurus* and smallest in *Exocetus* (cf. text-fig.). None of the characters used by Gill to characterize his two families is really distinctive. In *Scombrosœ*



Inner view of left ramus of lower jaw of: 1. *Exocetus arcticeps*.
2. *Chriodorus atherinoides*. 3. *Scombrosœ saurus*. 4. *Belone belone*.
s, sesamoid articulare; ar, articulare; an, angulare; d, dentary.

the form of the maxillary and its mode of attachment to the præmaxillary are exactly as in the Belonidæ, and the pharyngeal bones and teeth are much more similar to those of *Belone* and *Tylosurus* than to those of *Hemirhamphus* or *Exocetus* (cf. Pl. IX.). Zygapophyses are equally well developed in all the Synentognaths; throughout the group the neural arch of each vertebra has on each side a posterior

projection fitting an emargination of an anterior laminar expansion of the neural arch behind it; in the posterior caudal region the hæmal arches articulate in a somewhat similar manner, but on the anterior caudal and posterior præcaudal vertebræ the posterior processes are longer and directed vertically downward.

I find that the structure of the jaws, the pharyngeal bones and teeth, the skull, the pectoral arch, and the pelvic bones call for the recognition of two very distinct suborders, each including two closely related families.

Order SYNENTOGNATHI.

Suborder I. SCOMBRESOCOIDEA.

Synentognaths with small scales and with the mouth typically large, the jaws usually produced and narrowed forwards; rami of the lower jaw united by the interlocking of a series of inner processes (except in *Cololabis*); maxillaries firmly united to præmaxillaries. Third upper pharyngeals moderately enlarged, separate; fourth usually present; lower pharyngeal triangular or long and narrow. Pharyngeal teeth usually villiform or granular, some of the teeth of the principal plates often compressed, tricuspid. Parasphenoid without apophysis; myodome elongate, the parasphenoid and pro-otic meeting in a long sutural union; auditory bulla, if distinct, little prominent, with but a shallow depression in front of it. Post-temporal more or less expanded and laminar, simple or with a small inner fork; supra-cleithrum small, partly or entirely hidden by the post-temporal; cleithrum connected with basioccipital by a strong ligament. Each pelvic bone of an anterior subtriangular lamina and an erect laminar process, which is more or less expanded superiorly.

Family 1. Belonidæ.

Post-temporal forked, the upper fork more or less expanded, anteriorly attached to the nearly horizontal epiotic and pterotic lamina, the lower fork short and slender, attached to a process of the exoccipital lamina; supra-cleithrum small, vertical, more or less concealed beneath the post-temporal. Vertebræ 57 to 77 (57 in *Xenentodon**, 74 in *Potamorhaphis*, 77 in *Belone*); præcaudals with strong

* 57 also in the Miocene *Belone tenuis* (Kramberger, Glasnik Soc. Hist. Nat. Croatia, x. 1898, p. 26, pl. ii. fig. 1).

parapophyses to which the ribs are attached. Both jaws strongly produced, furnished with bands of small teeth and with a single series of more or less strongly enlarged, erect, conical, pointed teeth. No finlets.

Synopsis of the Genera.

- I. Gill-rakers developed; jaws comparatively slender; enlarged teeth of upper jaw moderate, of lower comparatively small and close-set; lower pharyngeal triangular; second and third upper pharyngeals dentigerous; fourth usually distinct, dentigerous.
 Body scarcely or moderately compressed. 1. *Belone*, Cuv., 1817*.
 Body very strongly compressed 2. *Petalichthys*, Regan, 1904.
- II. Gill-rakers absent or vestigial; jaws comparatively stout; enlarged teeth of both jaws strong, spaced canines.
- A. Dorsal rays subequal; lower pharyngeal triangular; second, third, and fourth upper pharyngeals separate, dentigerous.
 3. *Potamorhaphis*, Günth., [1866].
- B. Anterior dorsal rays forming a lobe; lower pharyngeal elongate, narrow, the dentigerous plate scarcely expanded posteriorly; second and third upper pharyngeals dentigerous; fourth usually distinct, dentigerous.
 Body scarcely or moderately compressed. 4. *Tylosurus*, Cocco, 1829.
 Body strongly compressed 5. *Athlennes*, Jord., 1886.
- C. Anterior dorsal rays forming a lobe; lower pharyngeal small, narrow, pointed or rounded at both ends; only one pair of dentigerous upper pharyngeals, the third.
 6. *Xenentodon*, gen. nov.

I have examined the pharyngeal dentition in the following species:—*Belone belone*, Linn., *acus*, Risso, *trachura*, Cuv. & Val., *platura*, Benn., *gracilis*, Lowe; *Petalichthys capensis*, Regan; *Tylosurus acus*, Lacep., *marinus*, Walb., *annulatus*, Cuv. & Val., *robustus*, Günth., *caudimaculatus*, Cuv., *strongylurus*, Bleek., *anastomella*, Cuv. & Val.; *Athlennes hians*, Cuv. & Val.; *Xenentodon cancila*, Buch. Ham., *canciloides*, Bleek.

The lower pharyngeal plate of *Xenentodon* seems to be derived from that of *Tylosurus* by the constriction off of the anterior part and disappearance of the remainder.

* According to the synonymy given by Dr. Gill, *Raphistoma*, Rafinesque, 1815, has priority over *Belone*, Cuv., 1817. Rafinesque ("Analyse de la Nature," p. 89) placed *Raphistoma* after *Esox* in the subfamily Esoxidia ("Une seule nageoire dorsale; dos non aiguillonné") of the family Siagonia ("Machoires très-prolongées, dentées") of the order Gastripia ("Les abdominaux"). The only generic diagnosis is a reference to *Belone*, Gr. [Gronovius]. As the name *Belone* apparently does not occur in the writings of Gronovius, *Raphistoma* may be regarded as a *nomen nudum*.

Family 2. Scombresocidæ.

Post-temporal simple, a broad lamina anteriorly overlapping the nearly vertical epiotic and pterotic lamina; supra-cleithrum a small bone adherent to the inner face of the post-temporal at its posterior edge. Vertebrae 65-70*, parapophyses mostly very short, with the ribs nearly sessile. Jaws more or less produced and attenuated forwards; teeth very small. Posterior rays of dorsal and anal detached finlets.

Two genera, *Scombrosox*, Lacep., and *Cololabis*, Gill. In both the pharyngeal bones and teeth are much as in *Belone*; the third upper pharyngeals are moderately large, separate, and are followed by the very small fourth pair, which bear a few teeth; the lower pharyngeals form a moderately broad triangular plate. In *Scombrosox* the structure of the jaws is exactly as in the Belonidæ, even to the presence of the interlocking processes which unite the produced portions of the rami of the lower jaw; the absence of these anterior extensions in *Cololabis* may be regarded as probably secondary.

Suborder 2. EXOCETOIDÆA.

Synentognaths with rather large scales and small mouth. Second and third upper pharyngeals dentigerous, the third pair strongly enlarged, together forming a somewhat convex ovoid plate; fourth upper pharyngeals absent; lower pharyngeal broad, triangular, with concave upper surface; teeth on principal pharyngeal plates anteriorly villiform, posteriorly incisors with transversely expanded horizontal edge, the two types connected by teeth of intermediate form, many of which are tricuspid. Parasphenoid with an inferior apophysis in front of the upper pharyngeals; myodome short, a deep depression between its outer wall and the prominent compressed auditory bulla. Post-temporal and supra-cleithrum simple, slender, curved, the former attached along the posterior edge of the pterotic lamina; supra-cleithrum suspended from the posterior end of the post-temporal; cleithrum curved inwards above, articulating directly with basioccipital. Each pelvic bone of an anterior subtriangular lamina and an erect slender process.

* 65 in *Scombrosox saurus*; 70 in the Miocene *Scombrosox acutirostris* (Sauvage, Ann. Sci. Géol. iv. 1873, no. 1, fig. 68, and xi. 1880, no. 3, p. 48).

Family 1. Hemirhamphidæ.

Præmaxillaries anteriorly forming a flat triangular expansion; maxillaries firmly united to præmaxillaries; teeth in jaws small, compressed, usually tricuspid; third upper pharyngeals ankylosed. Vertebræ 49 to 55; parapophyses strong, nearly horizontal. Pectoral fins short or moderately long.

Genera: *Cobitopsis* (probably including *Chriodorus*), *Arrhamphus*, *Hemirhamphus*, *Hemirhamphodon*, *Zenarchopterus*, *Dermatogenys*, *Oxyporhamphus*, *Euleptorhamphus*.

Hemirhamphus occurs in the Upper Eocene of Monte Bolca.

Cobitopsis acutus, from the Lower Miocene of France, is very closely related to *Chriodorus atherinoides* from the coast of Florida. Dr. Smith Woodward has permitted me to examine examples of the extinct species, which I have compared with specimens of *C. atherinoides*. The two agree in almost every detail; the form, position, and structure of the fins and the number of rays are exactly the same; the jaws, opercles, pectoral arch, &c. are extremely similar in the two species, and the number of vertebræ is nearly or quite identical. In an example of *Chriodorus atherinoides* I count 16 dorsal, 17 anal, 12 pectoral, 6 pelvic, and 13 branched caudal rays, and I find these numbers also in *Cobitopsis acutus*; I find 49 vertebræ in *C. atherinoides*, and approximately this number in *C. acutus*.

In making a restoration of the extinct species Dr. Smith Woodward* has evidently been influenced by Mr. Boulenger's opinion that this fish was related to *Ammodytes*. The broad cleithrum of the Hemirhamphidæ is represented as the enlarged suboperculum of the Ammodytidæ, and the pectorals are shown as symmetrical and placed low, whereas they appear to me to be asymmetrical and placed high. *C. acutus* has usually been described as toothless, but I believe that I can recognize traces of small teeth in the jaws of one of the specimens.

In *C. acutus* the head is longer than in *C. atherinoides*, measuring more than $\frac{1}{4}$ of the length of the fish to the base of the caudal, the lower jaw seems to be longer, more than $\frac{1}{2}$ the length of the head, and the snout is apparently more produced.

* Cat. Fossil Fish. iv. p. 355 (1901).

Family 2. Exocætidæ.

Præmaxillaries with straight transverse anterior margin; maxillaries free from or merely adherent to præmaxillaries; teeth in jaws minute, villiform; third upper pharyngeals simply coalescent, the plate readily separating into its two components. Vertebrae 44 to 52; most of the parapophyses directed somewhat downwards and forwards. Pectoral fins large.

Genera: *Exocætus*, *Halocypselus*, *Parexocætus*, *Fodiator*.

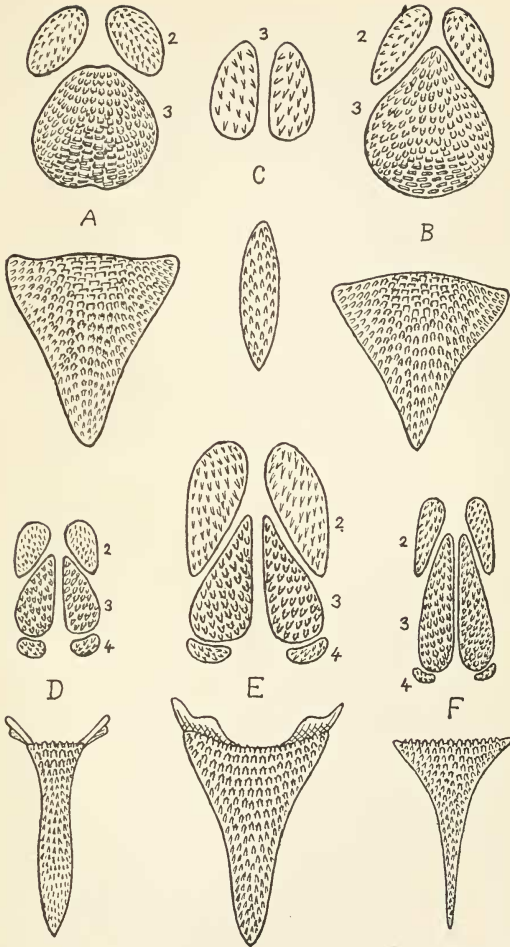
EXPLANATION OF PLATE IX.

Dentigerous pharyngeal bones of: A. *Exocætus lineatus*; B. *Hemirhamphus intermedius*; C. *Xenentodon cancila*; D. *Tylosurus acus*; E. *Belone belone*; F. *Scombrox saurus*. The second, third, and fourth upper pharyngeals are numbered.

XXXVII.—*Note on Parasitic Castration in the Earthworm Lumbricus herculeus.* By IGERNA B. J. SOLLAS, B.Sc., Newnham College, Cambridge.

ALL observations on parasitic castration have acquired fresh interest since the publication of Mr. Geoffrey Smith's work on the experimental analysis of sex (3). Also, so far as I know, no case of parasitic castration of a hermaphrodite animal is at present on record.

The castration described in this note attracted my attention in February 1910, when I found that of ten full-sized earthworms provided for demonstration purposes five possessed either no clitellum or an imperfectly developed clitellum, and in the abnormal individuals the seminal vesicles were either small and contained no sperm at any stage of development, or they were more or less normal as to size, but contained chiefly immature stages of sperm-cells. The spermathecae were empty; the ovaries were normal. In those worms in which the degeneration of the seminal vesicles was most complete not only was there no trace of clitellum, but the lips of the male duct were not tumid and the genital chætæ were not more prominent than the rest. Further batches of worms were obtained from the same locality, and rather less than half their number proved to lack the clitellum. A number of specimens without clitellum have also been found in various other localities.



PHARYNGEALS OF SYNGNATHI.

A-B. Exocætoidea ; C-F. Sombresocoida.